[CHAPTER 8]

Pesticide Residue Monitoring

Adulteration of foods and beverages by unscrupulous vendors was a centuries-old problem that worsened in the 19th century, as the nation became more urbanized and dependent on faraway sources of food. In 1887, the U.S. Bureau of Chemistry published a series of reports revealing that milk and wine were routinely diluted with water, pepper with dirt, and coffee with cereal. Aniline dyes were found in candies and toxic metals in canned vegetables. The majority of adulterants cheated consumers but were not harmful; however, poisonous adulterants were not uncommon, and people were sickened and even died as a result.

In 1906, Upton Sinclair's novel *The Jungle* exposed conditions at Chicago meat-packing plants, and triggered a public revulsion that pushed Congress into passing the Pure Food and Drug Act. It put the U.S. Bureau of Chemistry (reorganized in the 1920's as the U.S. Food and Drug Administration) in charge of protecting consumers against adulterated, misbranded, or impure food and drugs. Residues of arsenic and other toxic pesticides on food were but one of many food safety concerns, one that had surfaced periodically, beginning in the 1890s. That was to change as farmers took to using arsenic more often, and in greater quantities, to fight pests like codling moth, Colorado potato beetle, and the grasshopper.

Focus Turns to Pesticide Residues

In 1919, a city health inspector in Boston noticed a fruit stand with pears that were heavily spotted with a white substance resembling flour. An analysis revealed the white dust to be arsenic, sprayed on the trees during the growing season to control insects. The U.S. Department of Agriculture had analyzed a number of fruit samples and concluded that if arsenic was applied early in the growing season, residues should not be a health problem. However, federal authorities began a program to periodically examine fruit for residues and to educate farmers on the residue problem and encouraging them not to overspray fruit. Farmers also developed techniques to wipe or wash residues from their harvested crops. Between 1920 and 1925, despite reported illnesses and several well-publicized seizures of fruit with high arsenic levels by health officials in major American cities, state and federal officials continued to emphasize farmer education and persuasion about potential problems of overspraying.

In Great Britain, government control was stricter, after a 1900 tragedy in which 70 persons died and 6,000 were made ill because a brewer used arsenic-contaminated sugar in making his beer. As a result, England imposed a strict limit on the amount of arsenic allowed in food, including fresh fruit. In December 1925, a handful of illnesses among British consumers of American-grown fruit prompted the English authorities to analyze imports. Finding arsenic residues in excess of the allowable level, the British Health Ministry issued a warning not to eat imported apples, "especially . . . apples grown in dry foreign climates, where the apples are repeatedly sprayed during growth or the rainfall is not sufficient to wash off the deposit." Sales of fruit grown in California — an area of low rainfall and high pesticide use — plummeted, prompting State pesticide regulators in 1926 to begin analyzing small quantities of fresh produce for residues.

In 1927, the U.S. Bureau of Chemistry set the first federal limits (called tolerances) on allowable arsenic residues on apples and pears in interstate commerce and for export. The Bureau considered it health-protective, even though it was not as strict as the British tolerance. The Bureau was concerned about the economic impact of suddenly imposing strict residue limits on farmers, and decided to gradually reduce the tolerances as better

There should be neither misunderstanding nor ill feeling if shippers everywhere met spray residue regulations, and it cannot be too strongly stated that it is economically entirely practicable to meet them.
– 1938 Department annual report

equipment was developed for washing fruit. (This was done over the next several years and by 1932, the American tolerance was the same as Great Britain's.)

California's First Legislation

In response to Britain's 1926 threat of an embargo, the California Legislature passed the Chemical Spray Residue Act, which went into effect the day it was signed (May 28, 1927). It made it illegal to pack, ship, or sell fruits or vegetables with harmful pesticide residues. It also set residue tolerances for arsenic identical to those established by the federal government, and created a program to control residues of arsenic-based sprays on fruits and vegetables. California's new residue testing program was designed as much to promote marketing of the State's fruit as to safeguard consumers against harmful arsenic residues. The goal was to ensure that no shipments of California fruit were confiscated at their destination because of excess residues. All exports required a certificate of chemical analysis. The California Department of Agriculture (CDA) administered both an enforcement-oriented monitoring program, and a fee-based testing program that allowed growers to obtain State certification that their crops were free from arsenic residues.

By 1935, CDA was taking 22,000 samples a year in its voluntary certification program. (This service was phased out by the 1940s.) It was also taking about 3,000 enforcement samples, checking for illegal residues. Enforcement monitoring involved inspectors making daily visits to wholesale and retail markets in Los Angeles, San Diego and San Francisco. Laboratories in those cities analyzed the samples. When illegal residues were found, the lots of produce were quarantined and growers were instructed on how to remove residues with an acid wash. However, growers whose crops repeatedly had residues over allowable levels faced hefty fines and even jail sentences.

In 1934, the federal government set tolerances for residues of fluorine and lead, and California followed suit, expanding its monitoring to sample for these residues. With the introduction of many new synthetic organic pesticides in the late 1930s and 1940s, residue sampling expanded again to test for DDT and other organic compounds. In 1949, the Spray Residue Act was amended to include in the definition of a spray residue "any pesticide or constituent thereof which on produce is harmful to human health in quantities greater than a maximum amount or permissible tolerances established by rules and regulations of the Director." The amendments also gave the Director authority to set tolerances. Laws passed in 1967 and 1983 reinforced the right of California's Agriculture Director to review federal tolerances and adopt them in the State, or to set more stringent tolerances. With the creation of the Department of Pesticide Regulation (DPR) in 1991, that authority was transferred to the DPR Director. (Federal legislation passed in 1996 preempted states from setting their own tolerances.)

In 1950, with the use of the new synthetic chemicals increasing, the Department noted a decline in arsenic residues. The report described arsenic as "one of the oldest spray residues on fruits and vegetables. At one time it was the only poisonous contaminant likely to be found . . . the only one in which there was public health interest, and the only one for which a tolerance was established in California law." By 1950, there were few residues of arsenic, lead, and fluorine; DDT was the most common residue found. Despite the wide variety of chemicals used, there were only four tolerances on the books: arsenic, lead, fluorine and DDT.

The U.S. Food and Drug Administration (U.S. FDA) held nine months of hearings in 1950 on setting tolerances for the newly introduced organic pesticides, collecting more than 8,000 pages of testimony presented by 246 witnesses, among them the chief of California's pesticide regulatory program. He reported that year that the hearings "brought to general attention the previous lack of dependable information on the kind and magnitude of spray residues found on produce commonly marketed." In 1955, the U.S. FDA issued tolerances for 60 different pesticides on many crops.

In 1953, the Legislature amended the Spray Residue Act to cover grains used to feed livestock or poultry. This was in response to the Department of Agriculture's concerns that it could not take legal action in cases where pesticide misuse contaminated anything other than fruits or vegetables.

Enforcement work must be reasonable, avoiding hysteria, and simultaneously evaluate all factors. It is unfair knowingly to exaggerate a case to the extent that people, in order to escape a hypothetical danger, will avoid sprayed products entirely, and thereby deprive themselves of valuable foods. With continuation of careful enforcement, the proportion of low-residue fruits and vegetables continues to be satisfactory.
– Dr. Alvin J. Cox, head of the Department's pesticide regulatory program, in a 1941 article for the American Journal of Public Health, cited in 1942 annual report

At the federal level, the Food, Drug, and Cosmetic Act was amended in 1954 to prohibit registration of any food-use pesticide that left residues until and unless the U.S. FDA issued a tolerance that sanctioned "safe" residue levels.

The 1980s saw a dramatic increase in concern about pesticide residues in food, particularly fresh produce. Widespread public attention was drawn to the issue in 1984 when the Natural Resources Defense Council (NRDC) published a report entitled, *Pesticides in Food, What the Public Needs to Know*. The theme of the report was like many to follow: that government pesticide residue monitoring programs were not doing an adequate job of protecting public health.

The NRDC report was followed by a 1985 study from the Commission on California State Government Organization and Economy ("Little Hoover Commission") entitled *Control of Pesticide Residues in Food Products: A Review of the California Program of Pesticide Regulation*. This report highlighted deficiencies in CDFA's monitoring of fresh produce, and criticized the Department of Health Services (DHS) for not conducting routine pesticide residue monitoring of processed foods.

The presence of pesticide residues in food received worldwide attention in July of 1985 when widespread illnesses were reported by persons who ate California-grown watermelons that contained illegal residues of the pesticide aldicarb. This misuse of aldicarb — a criminal act by a handful of growers — was often cited as an example of the failure of the regulatory system.

Federal agencies that monitor the food supply were not exempt from criticism. The U.S. General Accounting Office targeted them in two 1986 reports, *Pesticides: Better Sampling and Enforcement Needed on Imported Food, and Pesticides: Need to Enhance FDA's Ability to Protect the Public from Illegal Residues.*

It is of paramount interest to California's agricultural economy that the healthfulness of its products is beyond question.
– 1946 Department annual report

California Expands Residue Monitoring

The flurry of interest and activity sparked a variety of responses. In 1985, partly in response to criticisms in the Little Hoover Commission report, the Department expanded its residue monitoring system. Funded in part by a budget augmentation and partly by legislation, more than $2 million was added to the Department's budget to create three new monitoring program elements to complement marketplace surveillance, and to almost double the number of samples analyzed. The new monitoring elements began in 1987 and included a program to test raw produce destined for processing (established and funded by Chapter 1285, Statutes of 1985, AB 1397) and another to sample crops before harvesting. The third monitoring element (called Focused Monitoring and later Priority Pesticide Program) targeted sampling of commodities known to have been treated with pesticides of health concern. The goal was to collect data to assist in making accurate assessments of dietary risk.

In 1987, the National Academy of Sciences (NAS) issued a report which further reinforced public concerns about food safety. This report, *Regulating Pesticide Residues in Food: The Delaney Paradox*, examined the effect that the Delaney clause of the Federal Food, Drug, and Cosmetic Act had on U.S. EPA's regulation of pesticide residues in food. (The Delaney Clause, added to law in the 1950s, prohibited additives in processed foods that are found to induce cancer in humans or animals. In 1996, the Delaney Clause was repealed with passage of the omnibus Food Quality Protection Act.) As part of its examination, the NAS committee developed theoretical estimates of risk from dietary exposure to 53 potentially carcinogenic pesticides used on food crops.

In 1988, the State's Assembly Office of Research published *The Invisible Diet: Gaps in California's Pesticide Residue Detection Program*, which was highly critical of both DHS and CDFA. And in March 1989, the NRDC issued the report, *Intolerable Risk: Pesticides in Our Children's Food.* It concluded that preschoolers are being exposed to dangerous levels of toxic pesticides in both fresh and processed foods and generated a tremendous amount of media attention and controversy.

The NRDC report also prompted renewed attention from the State Legislature on food safety and contributed to passage of the Food Safety Act of 1989 (Chapter 1200, AB 2161), which added and expanded several sections in the Food and Agricultural Code and the Health and Safety Code. The statute required increased priority pesticide

monitoring; established a scientific advisory committee to review residue analytical methods; established a committee to fund research into alternative pest management practices; required risk assessments on the dietary exposure to pesticides in both raw and processed foods; gave the Department authority to call in acute toxicity studies where needed to support risk assessments; required the Department of Health Services to commence a processed food monitoring program; and required private laboratory accreditation and reporting by private laboratories of findings of illegal pesticide residues in the channels of trade. The bill also gave the Department clear statutory authority to require full pesticide use reporting.

The legislation also required that DPR and the State Department of Health Services jointly review the State and federal pesticide registration programs to determine if infants and children were adequately protected from dietary pesticide residues. The review was to take into consideration an evaluation of the federal registration program being undertaken by the National Academy of Sciences (NAS).

When the NAS released its report in June 1993, Cal/EPA formed the Pesticide Exposure to Children Committee (PECC), with scientists representing DPR, DHS, OEHHA, CDFA, U.S. EPA, and the University of California. Their conclusions were presented in a May 1994 report to the Legislature. The PECC concluded that "the current California and federal pesticide regulatory systems adequately protect infants and children from risks posed by pesticide residues in the diet," while citing "potential areas for improvement of the pesticide registration and food safety programs." The committee called on DPR, "in its role as the lead agency for pesticide regulation," to continue efforts to work with U.S. EPA "to achieve greater harmony in pesticide regulatory programs." The committee also made a number of recommendations on enhancing the risk assessment process, many of which have been carried out. For example, the committee recommended that DPR and U.S. EPA assess pesticide risk not only from a dietary standpoint but consider other possible routes of exposure, including drinking water and home pesticide use, an approach that was adopted by the end of the decade.

Sensitive and accurate chemical methods have been developed to examine produce for traces of spray residue and the methods have been streamlined to minimize the time required for analysis. To shorten the time still further, this Department maintains field laboratories .... Speed is essential to determine promptly whether a suspected lot should be passed or quarantined out of sale.
– 1947 Department annual report

With the passage of AB 2161, the number of samples taken in the four monitoring elements reached an annual high of more than 12,500 samples in 1989, and remained high through the early 1990s before declining to about 8,000 by 2000. At the same time, the Department also enhanced its analytical capabilities. In 1988, residue program chemists were using multiresidue analytical methods (called screens) that could detect 108 pesticide active ingredients, metabolites, and breakdown products; by 1991, that number had increased to more than 200. The testing results are usually available within eight hours.

Budgetary cutbacks in 1992 and 1993 prompted the reduction and then the cessation of the preharvest and produce destined for processing programs. These programs had been designed to address specific concerns, respectively, the use of illegal pesticides before harvest and the presence of pesticides on produce destined for processing. Because monitoring in these programs had demonstrated consistently lower percentages of detectable residues and lower rates of violations than in the Marketplace Surveillance Program, their suspension was not expected to adversely affect food safety. In mid-2000, the Priority Pesticide Program was combined with the Marketplace Surveillance Program to take advantage of the increased utility of full use reporting data and to improve quality control over sampling and analysis.

Marketplace Surveillance Program

DPR samples individual lots of domestically produced and imported foods and analyzes them for pesticide residues to enforce the tolerances set by U.S. EPA. Samples are collected from throughout the channels of trade — at points of entry (seaports and State border stations), packing sites, and the wholesale and retail markets. Pesticide Enforcement Branch staff collect most samples, although County Agricultural Commissioners collect many point-of-origin (e.g., packing sites) samples. All samples are tested with multiresidue screens *(see Testing Methods below)*. In addition, selected samples receive specific analysis for nonscreenable pesticides of enforcement concern.

DPR samples only fresh produce (the Department of Health Services has authority over processed food). The samples are analyzed as unwashed, whole (unpeeled), raw commodity. If illegal residues are found (either above the U.S. EPA tolerance or with no tolerance established for that particular food/pesticide combination), DPR can invoke various sanctions. *(See Chapter 7 for information on enforcement and compliance options.)*

Domestic and imported food samples collected are classified as either "surveillance" or "compliance." Most samples that DPR collects are the surveillance type; that is, there is no prior knowledge or evidence that a specific food shipment contains illegal pesticide residues. DPR takes compliance samples as follow-up to the finding of an illegal residue or when other evidence suggests that a pesticide residue problem may exist. (An illegal residue is one that is above the tolerance level or any residue of a pesticide not allowed to be used on the commodity.)

The data collected under regulatory monitoring are extensive; however, they are not statistically representative of the overall residue situation for a particular pesticide, commodity, or place of origin. Some sampling bias may be incurred by weighting toward such factors as commodity, place of origin with a history of violations, or large volume of production or import. In addition, the total number of samples of a given commodity analyzed for a particular pesticide each year may be insufficient to draw specific conclusions about overall residues for a commodity in commerce.

Under a statutory mandate (FAC 12532, Statutes of 1986, Chapter 1375, SB 1889), the focus of the residue monitoring program is to prevent "public exposure to illegal pesticide residues." Therefore, residue monitoring is directed toward enforcement of U.S. EPA tolerances. (An additional benefit of merging the Priority Pesticide with the Marketplace Surveillance Program is that all sample results are now enforceable. Because the focus of the Priority Pesticide Program was data gathering, analyses were typically not done until days or weeks after the sample was collected. If illegal residues were found, no enforcement action could be taken because of the difficulty of investigative followup.)

The Department investigates every case of an illegal residue detected in its residue monitoring programs. Enforcement staff interview shippers and packers to learn where the produce was grown. If the produce came from out of State, the produce remains under quarantine and information is forwarded to U.S. FDA for further enforcement action. If the produce was grown within California, enforcement staff interview growers, pest control applicators, and others to learn how the produce was contaminated before determining appropriate enforcement action. *(For information on enforcement and compliance options, see Chapter 7.)*

About 8,000 samples are taken annually of about 150 different kinds of commodities. Eighty percent of the samples are of approximately 75 commodities important in the diets of infants and children, or in the population overall. With the merging of the Priority Pesticide Program with Marketplace Surveillance sampling, dietary risk assessors gained significantly more data. Under the Priority Pesticide Program, there had been a limited number of samples taken of each commodity and each was typically analyzed for a single pesticide among a small group of chemicals under regulatory scrutiny. In the Marketplace Surveillance Program, a larger number of samples are taken of each commodity, and each is analyzed using multiresidue screens capable of detecting more than 200 pesticides and breakdown products. This data is especially useful to dietary risk assessors focusing on the cumulative dietary impact of multiple residues of pesticides with similar biological modes of action. (The federal Food Quality Protection Act mandated that dietary risk assessment consider this cumulative exposure to pesticides.)

Under a statutory mandate (FAC 12532, Statutes of 1986, Chapter 1375, SB 1889), DPR annually publishes a summary overview of the residue monitoring program in the Pesticides in Fresh Produce report. The Residue Monitoring Program is the most extensive State residue monitoring program in the nation. Managed by Pesticide Enforcement Branch, it is the final check in an integrated network of programs designed to ensure the safe use of pesticides in California.

The rapid strides being made in the development and use of new agricultural chemicals require a similar and concurrent development of analytical methods. Adequate analytical technique is essential … in securing accurate information on dosages, dilutions, and applications of the chemicals and in following the fate of chemicals in mixtures and as residues on treated plants.…
– 1945 Department annual report

Testing Methods

The analytical methods used to measure pesticide residues are generally capable of determining levels well below tolerances (legally allowable residue levels). DPR tests samples using both multiresidue screens, capable of detecting a large number of pesticides, as well as specific analyses for targeted pesticides.

CDFA's Center for Analytical Chemistry provides testing and analytical methods development services to DPR. The laboratory analyzes for pesticide residues in fresh produce and environmental samples (foliage, soil, air and water). As part of DPR's pesticide registration process, a registrant must provide acceptable analytical methods for any active ingredient registered for use in or on food crops. The registrant must also provide analytical methods for all metabolites of regulatory significance. CDFA's laboratory evaluates these methodologies to determine their validity, speed and feasibility. Laboratory scientists also develop new testing methods for DPR, particularly multiresidue screening methods that are faster and capable of detecting a wider range of materials. The laboratory develops residue methods for sampling on nontarget crops, soil, water, and other materials to assist in evidence collection during misuse investigations.

The spray residue program protects the health of consumers of fresh and dried fruits and vegetables through sampling and analyzing produce to make certain that it does not carry spray residue in excess of the tolerances permitted by law.
– 1947 Department annual report

Coordination with Federal Agencies

The effectiveness of DPR's pesticide residue monitoring program is enhanced by a cooperative monitoring agreement with the U.S. FDA, which monitors raw and processed food nationwide. DPR and U.S. FDA staff meet regularly to plan sampling strategies that complement rather than duplicate each other. The two agencies share monitoring results and cooperate on investigations.

The U.S. Department of Agriculture (USDA) has cooperative agreements with DPR to sample selected commodities and with CDFA to analyze them for pesticide residues. In 2000, California was one of 10 states involved in this nationwide project, known as the Pesticide Data Program (PDP). USDA started the PDP in May 1991 to provide data on pesticide dietary exposure, food consumption, and pesticide usage. U.S. EPA uses the data to help make more realistic assessments of dietary pesticide risk, and for its ongoing review of pesticide tolerances.

The focus of USDA's PDP is gathering comprehensive data on minute traces of residues. To do this, multiresidue methods were enhanced to be sensitive to residue levels of significantly less than 50 parts per billion. California's participation in PDP helped produce significant enhancements of the multiresidue screens that can simultaneously detect many pesticides.